Journal of Environmental Management 95 (2012) S154–S157

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Used battery collection in central Mexico: Metal content, legislative/management situation and statistical analysis

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ARTICLE INFO

Article history:
Received 29 September 2009
Received in revised form
1 September 2010
Accepted 9 September 2010
Available online 8 October 2010

Keywords:
Batteries
Campaign
Metal
Management
Mexico

ABSTRACT

A statistical analysis of a used battery collection campaign in the state of Tlaxcala, Mexico, is presented. This included a study of the metal composition of spent batteries from formal and informal markets, and a critical discussion about the management of spent batteries in Mexico with respect to legislation.

A six-month collection campaign was statistically analyzed: 77% of the battery types were "AA" and 30% of the batteries were from the informal market. A substantial percentage (36%) of batteries had residual voltage in the range 1.2–1.4 V, and 70% had more than 1.0 V; this may reflect underutilization. Metal content analysis and recovery experiments were performed with the five formal and four more frequent informal trademarks. The analysis of Hg, Cd and Pb showed there is no significant difference in content between formal and informal commercialized batteries. All of the analyzed trademarks were under the permissible limit levels of the proposed Mexican Official Norm (NOM) NMX-AA-104-SCFI-2006 and would be classified as not dangerous residues (can be thrown to the domestic rubbish); however, compared with the EU directive 2006/66/EC, 8 out of 9 of the selected battery trademarks would be rejected, since the Mexican Norm content limit is 20, 7.5 and 5 fold higher in Hg, Cd and Pb, respectively, than the EU directive. These results outline the necessity for better regulatory criteria in the proposed Mexican NOM in order to minimize the impact on human health and the environment of this type of residues.

1. Introduction

Environmental pollution produced by disposal of Spent Cells and Batteries (SCB) is a major concern due to the fast growing portable electronic equipment industry that generates thousands of tons of dangerous residues per year. Based on 1992 and 1998 studies, household batteries accounted for approximately 90% of the Hg and 52% of the Cd in Municipal Solid Wastes (MSW) in the US, though that level is projected to decline greatly as manufacturers remove mercury from alkaline batteries (Richard and Woodbury, 1992, 1998). In the EU, the environmental risks related to the disposal of the Cd batteries were assessed in the draft Targeted Risk Assessment Report, "Cadmium (oxide) as used in batteries" (TRAR, 2003). According to the report, the Cd emissions of portable NiCd batteries due to landfill were calculated at 131–655 kg of Cd per year. In 2006, the European Commission required a closed cycle system for all the SCB (Directive 2006/66/EC, 2006) with the purpose of reduce the quantity of spent batteries and accumulators and to set targets for collection and recycling. The US Department of Health and Human Services' Agency for Toxic Substances and Disease Registry states that the metals in batteries can have serious health effects if not managed correctly. Hg at high levels can damage the brain, kidneys and a developing fetus. Pb can harm the nervous system, kidneys and reproductive system. Cd can damage the lungs and kidneys, and irritate the digestive tract. Exposure to large amounts of Zn can cause stomach cramps, anemia and changes in cholesterol levels. And each metal can have a direct harmful effect on the environment (ATSDR, 2010).

The first legal precedent for regulation of SCB in México arose in 1988 with the general law of the ecological balance and the protection of the environment (LGEEPA). This law classifies the SCB as potential dangerous residues given the toxicity risk of some of its components, although the inadequate handling of SCB has continued being a common practice. Mexico's National Institute of Ecology (INE) estimates that from 1960 to 2003, the following residues have been deposited in MSW: 145,918 ton of MnO_2;

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0301-4797/$ – see front matter
doi:10.1016/j.jenvman.2010.09.019

1232 ton of Hg; 22,063 ton of Ni; 20,169 ton of Cd and 77 ton of Li compounds (Castro-Díaz and Díaz-Arias, 2006). The Mexican Association of Manufacturers and Commercial Dealers of Batteries (Amexpilas) claims their batteries do not pollute the environment and have made efforts to convince public opinion only informal batteries (which have questions regarding legal registrations and corresponding business procedures) are polluting (Vega-Vieyra, 2006). The total market (single use and rechargeable) is approximately 650 million batteries per year. This corresponds to about 500 and more than 200 million dollars per year for formal and informal batteries, respectively (Aguilar and García-Camargo, 2006). In 2006, the federal government made public the proposed Mexican Official Norm (NOM) NMX-AA-104-SCFI-2006. There are important differences between the EU directive 2006/66/EC and the proposed Mexican NOM: the maximum permissible levels for Hg, Cd, and Pb are 20, 7.5, and 5 times, respectively, higher than the EU directive, and approved legal batteries are permitted to be discarded in landfills.

Since the article was first submitted, the Mexican Republic Senate urged the Secretariat of Environment and Natural Resources to implement a comprehensive management program of SCB, and requested that the head of the Department of Environment and Natural Resources report the situation of the proposal PROY-NMX-AA-104-SCFI-2006, asking for its publication if it had completed the consultation process (Mexican Senate, 2009). However, the proposal has not advanced, and some specialists are afraid that the legislation, rather than encouraging the recycling of batteries with the responsible participation of consumers, producers and local authorities, became a disincentive to do so (Cortinas de Nava, 2009). Other Latin-American countries have similar situations: official policies and regulations only establish limits to the potentially hazardous metal content used on batteries' composition but do not mandate the participation of producers and importers. In Argentina, an environmental organization demanded the publication of a law which provides for extended producer responsibility, but it was delayed in the Senate (Greenpeace-Argentina, 2010). In Colombia, the proposed law No. 69 (2009) of the Republic Senate contemplates repurchase of batteries, and electrical and electronic waste by the manufacturers (Gladis, 2009). In Brazil, the CONAMA regulations (2001) prohibited the marketing of batteries with concentrations higher than the stipulated limits of Hg, Cd and Pb, but batteries with lower content can be landfilled. A broader and potentially more effective regulation was established by the Brazilian State of Rio Grande do Sul, where law 11.187 (1998) prohibits the disposal of any material containing heavy metals together with MSW (Soares Tenório, 2003).

In this work, an official program to collect SBC in Central Mexico was used to: 1) conduct a statistical evaluation of the incidence of informal commerce batteries compared to the formal ones; 2) study the residual voltage of SBC to help assess optimal use of this energy source and the potential inclusion of residual energy recovery as part of recycling technology; and 3) study the metal composition of used batteries from formal and informal market to determine if there is a significant difference in their metal content. The objective of this paper was to use these results to evaluate the potential effectiveness of proposed Mexican NOM by classifying both types of SCB (formal and informal market) under this NOM and the EU directive 2006/66/EC.

2. Materials and methods

2.1. Compilation of spent batteries

The collection of spent batteries was carried out from June 2007 to January 2008 in the city of Tlaxcala and its municipal territory (area of 52.449 Km^2 and 83,748 inhabitants). A collection point was installed in every one of the eleven auxiliary municipal presidential offices.

The exhausted portable batteries from the collection points were concentrated and separated in trademarks, models, and the market of origin (formal or informal). Residual voltage of random selected batteries type "AA" from the four major trademarks was measured. Statistical analysis was made with the program Origin V6.1. The collected batteries reflected what the local population voluntarily brought to the collection centers. Although we did not

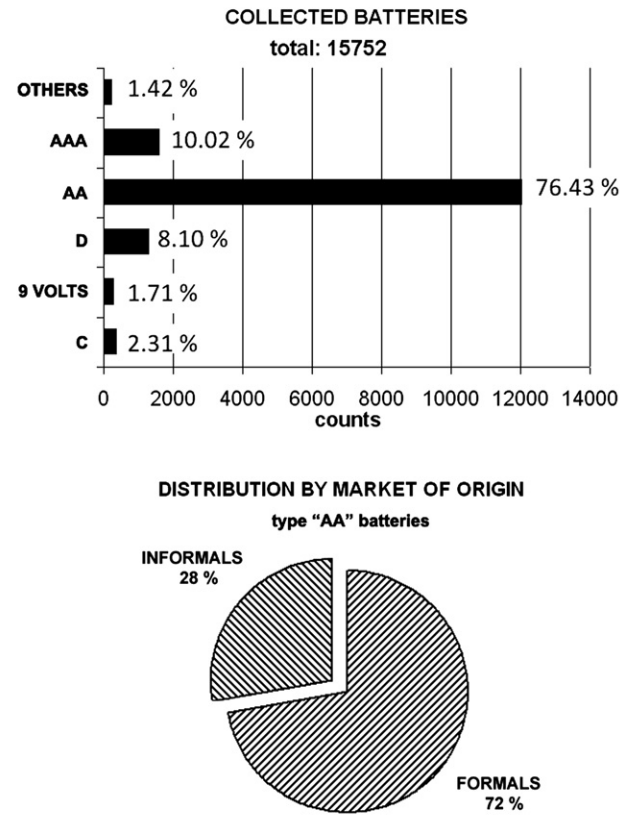

Fig. 1. Statistical results for the used batteries collection campaign. Above: Distribution by type of battery; Below: Cake plot for market of origin of type "AA" batteries. A cake plot for distribution of trademarks (formals and informals) can be consulted in the Supplementary material.

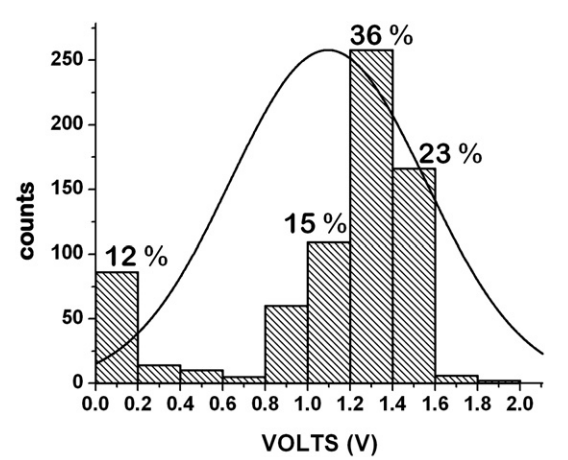

Fig. 2. Distribution of voltages frequency for Duracell type "AA" batteries collected.